

# Motorsports Medicine

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Motorsports is the fastest growing professional sport in the United States. Each year approximately 14 drivers die, and many others are paralyzed or seriously injured. Although there is a common misconception that motorsports medicine is analogous to standard emergency or sports medicine, due to the unique racing environment a traditional approach to emergency medical services can be ineffective and may expose drivers, spectators, and medical personnel to great danger. This article is a general review of the evolving subspecialty of motorsports medicine.

## Introduction

Motorsports is the fastest growing professional sport in the United States [1]. Each year approximately 14 drivers die, and many others are paralyzed or seriously injured. Surprisingly, 27% of those killed at auto racing events are track workers, spectators, and journalists [2]. Although there is a common misconception that motorsports medicine is analogous to standard emergency medical services (EMS) or sports medicine, due to the unique racing environment a traditional approach to EMS can be ineffective and may expose drivers, spectators, and medical personnel to great danger.

Motorsports medicine is unique due to a number of factors. First, medical personnel are required to navigate racetracks simultaneously with speeding cars, boats, or motorcycles. Second, medical personnel must be knowledgeable regarding numerous vehicle configurations, crash characteristics, sanctioning body rules, and fuel characteristics. Third, environmental factors such as heat, isolation from typical medical resources, and constantly changing safety equipment can uniquely impact patient care. Fourth, medical personnel may be required to provide patient care in a potentially dangerous environment, such as near speeding trucks during an off-road desert race. Fifth, medical personnel require specialized training in extrication and packaging of patients from various types of race vehicles such as Indy cars, stock cars, motorcycles, off-road buggies, motorcycles, and boats. Sixth, drivers have an increased tendency to refuse necessary medical care due to their vested financial and emotional interest in the race. Seventh, medical personnel

may have unique time constraints such as those of a live television broadcast. Finally, the decreased incident to patient assessment time interval may initially prevent the recognition of serious injuries due to the lack of time for bleeding and swelling to take place and adrenaline to subside.

Due to the diversity of motorsports, rapidly evolving safety issues and techniques and potentially dangerous racing environment this article should not be construed as a comprehensive review to allow medical personnel to practice motorsports medicine. This article is a general review of motorsports medicine, with an emphasis on interesting and important new findings. Although many motorsports events involve mass gatherings, this article focuses primarily on the unique aspects of medical care for the participants and does not address spectator care [3].

## Literature Review

Although motorsports is increasingly popular, surprisingly very little has been published in the medical literature. From 1965 until 1989 only 24 articles that focused on motorsports were found. Most of these articles were descriptive in nature, detailing the various types of injuries, causes of deaths, and how to plan for medical support of motorsports events. Since 1990, 39 articles focused on some form of motorsports have been published in the English language medical literature; 15 of these articles described medical support or injuries for specific venues [4-18], 10 focused on the health effects of tobacco and other sponsorship at motorsports events [19-28], and three described the risk of hearing loss for racers [29-31]. Additionally, there were two articles discussing each of the following: the visual aspects of competition [32,33], the risk of carbon monoxide exposure [34,35], and the psychology of motorsports [36,37]. One article described intoxication with nitromethane fuel during a drag racing accident causing abnormal creatinine laboratory test results [38], and another article surveyed traveling motorsports teams regarding their travel preparations [39].

Although some have argued that racecar drivers are not real athletes, others have argued contrarily. One of the most important motorsports medicine articles published recently demonstrated that the oxygen consumption and heart rate responses to road course driving were similar to those previously reported in traditional sports settings, and thus racecar drivers should be regarded as athletes that encounter significant physiologic stresses [40•].

Although some have argued that physicians aren't necessary at large motorsports events, others have believed that on-site physician-level care can improve care at such events.

The only prospective study to determine if physicians really made a difference was recently published. It found that 52% of patients could be treated and dispositioned by a paramedic, 39% of patients required a nurse level of care, and 9% required care that only a physician could provide. In addition, 89% of ambulance transports could be prevented if a physician was available at a motorsports event. Due to the high-risk nature of motorsports, the authors believe that the standard of care for a major motorsports event is to have a physician with training and experience in prehospital care and emergency medicine on-site during any on-track competition [41•].

Numerous racecar drivers have died recently due to significant neck fractures and basilar skull fractures. This is commonly believed to be due to the combination of the sudden deceleration upon impact, the well-restrained torso, the increased mass of the head (helmet, masks, etc.), and the unrestrained head. Although much research and application of such research has been done recently to minimize these types of injuries, little has been published in the medical literature regarding head and neck restraint devices. Panin and Prusov [42•] introduce the above concept into the medical literature for the first time and discuss the challenges of developing a device to protect the neck during significant deceleration incidents. Because much of motorsports medicine has been focused recently on trying to reduce these particularly horrific injuries, this article is a "must-read" for anyone interested in practicing motorsports medicine.

Although not part of the medical literature, probably the most important single document ever published regarding safety at motorsports venues was just published by the National Fire Protection Association (NFPA): *NFPA 610 Guide for Emergency and Safety Operations at Motorsports Venues* [43••]. Although much of the document is concerned more with the fire and safety aspect of operations, the document does address certain medical issues as well. It was derived by experts from almost every aspect of motorsports, including major sanctioning bodies, insurers, track owners, fire/safety directors, and medical directors. This document is the first consensus-based document to address safety at motorsports venues by any national organization and is bound to become the yard stick by which all venues will be measured. Due to the consensus nature of the process to write such a guide, however, certain aspects of the guide were watered down. For instance, although most of the experts on the panel felt that an advanced life support (ALS) ambulance was the minimum level of care that should be at a motorsports event, members from one state said that they didn't even have ALS ambulances in their entire region, so there is no way that they could be compliant. Thus, the wording of recommended levels of medical care had to be diluted so that it could be applicable across the entire country. For anyone involved in medical care at a major motorsports venue, this document, however, is another must-read.

## Planning

The most important part of any motorsports event is the planning stage. A medical action plan should outline specific details about the organization and delivery of emergency medical care at the specific race. The medical action plan should be customized to the type of racing, sanctioning body requirements, location, and specific event based upon experience and statistics from previous similar events. Every medical action plan should address the following components: physician medical oversight, level of care, human resources, specialized medical equipment, treatment facilities, transportation resources, emergency medical operations, communications, command and control, documentation, and continuous quality improvement.

A locally licensed physician should be appointed to oversee medical care at every large motorsports event and should actively participate in the design and implementation of the medical action plan. Both indirect (protocols) and direct (on-site) medical oversight is important. The medical literature clearly demonstrates that on-site physicians can positively impact decision making and care in the field [18,41•].

A traveling medical director and safety team can also be an asset to the planning process. These individuals not only have the advantage of experience with the specific race vehicles and extrication experience, but also have personal knowledge of driver injury history and "quirks" (behaviors unique to certain drivers). Because all states currently require a unique state license to practice medicine, traveling medical directors are generally restricted by the law to a consultant role and aren't able to legally provide hands-on care. Although this generally applies to traveling nonphysician medical personnel also, some states have provisions that allow for temporary certification of paramedics for special events such as motorsports races [44].

A plan for the level of medical care to be provided should exist prior to every motorsports event. Although not always needed, physicians are able to provide an expanded scope of practice such as a surgical cricothyrotomy, rapid sequence intubation, other advanced alternative airway, and amputation, which have been shown to save the lives of drivers [45]. Although it is recognized that smaller venues and promoters may not be able to afford qualified physician coverage, many large venues and sanctioning bodies now require a physician with emergency medicine and prehospital experience expertise to be on site during any on track activity.

Because most motorsports deaths and serious injuries involve the head, neck, and airway, most experts agree that an ALS ambulance is the minimum level of medical care that should be on site during any competitive motorsports activity. Although a basic life support ambulance can provide appropriate spinal immobilization and basic airway adjuncts, the operators are generally not trained in advanced airway techniques. Thus, most experts strongly discourage the use of anything less than an ALS ambulance crew during any major motorsports event.

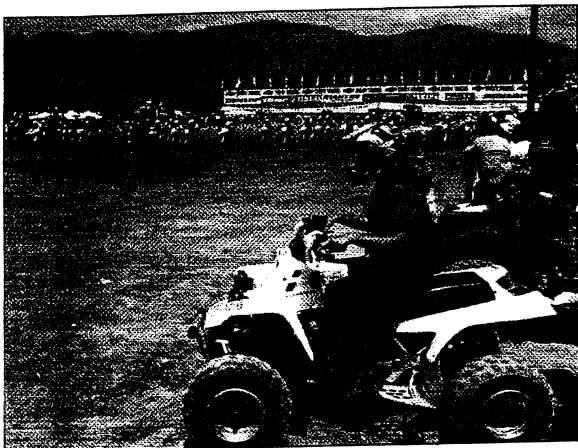


Figure 1. Specially trained and equipped paramedic at the start of an American Motorsports Association Motocross Championship at Glen Helen Raceway (San Bernardino, CA).



Figure 2. A paramedic evaluates an injured motocross rider in front of a mobile first aid station.

A basic human resource plan that addresses roles and responsibilities for medical personnel and logistic issues surrounding their deployment should exist. This plan should address the numbers of medical personnel necessary to deliver appropriate care for the expected numbers of drivers at the particular race. Although it is impossible to always predict the numbers of patients you will treat at any motorsports event, good medical reconnaissance and experience should, in general, provide you with an acceptable estimate. The number of medical personnel should be enough to adequately care for the worst crashes historically seen with the particular type of racing. All medical personnel must also be appropriately certified, licensed, or accredited to practice their medical specialty in the jurisdiction in which the motorsports event is being held.

A basic medical equipment plan addressing the highest anticipated level of care should be in place. The plan should describe what medical supplies and equipment will be carried in both fixed treatment facilities and any mobile medical

units. As always, the ABCs (airway, breathing, circulation) should be addressed first and foremost. Therefore, equipment and supplies such as defibrillators, endotracheal tubes, laryngeal mask airways, combitubes, percutaneous cricothyrotomy kits, bag-valve-masks, cervical collars, backboards, airway confirmation equipment, and any safety gear are most important. Nonmedical equipment such as blankets, sunscreen, ear plugs, radios with headsets, extrication equipment, helmet visor removal tools, fire suits, fire trucks, ambulances, and specialized emergency response vehicles should also be considered in this part of the plan (Fig. 1).

On-site medical treatment facilities are usually only present at large motorsports venues, or those that last for an extended period of time or have long transport times to definitive care (Fig. 2). The exact facilities will depend on the specific event, human resources, and financial resources. It is important to remember that on-site facilities shouldn't delay transport of critically injured or ill patients to definitive care. The capabilities of all off-site facilities (trauma centers, burn centers, neurosurgery, cardiothoracic surgery) should be clear to all medical staff, so each patient can be transported to an appropriate hospital. In my experience, due to the increasing popularity and press coverage of motorsports, some hospital administrators are arguing for these patients to be transported to their facility, unfortunately, sometimes to the detriment of patient care. For instance, more than one administrator of a hospital without the capability to handle aortic injuries has argued that he should receive any high-profile drivers rather than sending them to a level 1 trauma center that is only slightly further away, apparently due to financial and marketing opportunities. Because blunt thoracic aortic injury is highly lethal and second only to closed head injuries among deaths attributable to blunt trauma [46], it is extremely important that patients with possible aortic injuries be sent to facilities with the capability to handle such emergencies as medically appropriate. Although it isn't always easy or popular, it is the duty of the physician responsible for medical care at motorsports venues to ensure appropriate patient care regardless of the local political and financial issues.

A plan for deploying emergency response resources should be in place prior to any large event. Transportation resources may include ground ambulances, air ambulances, boats, motorcycles, and other specialized emergency response vehicles. Although there are many theories on how best to utilize emergency transportation resources, every motorsports event is different and therefore requires thought in how to best utilize such resources. Consideration should be given to the following: minimizing response times, safety of caregivers, minimizing vehicle transport through congested areas, designated parking, and designated restricted emergency access routes. Whenever helicopters may be used to transport patients, a dedicated landing zone should be established and secured prior to the start of the event.

A basic emergency operations plan that addresses elements of responsibility for fire suppression, responsibility for rescue/extrication, responsibility for medical care, scope of

medical care, anticipated duration of operations, geographic limits of medical operations, and medical team roles should be in place. The plan should address the relationship with other functional components such as security and law enforcement, venue administration, and public relations. The plan should address any plans in the unfortunate instance of an on-track death. The plan should also address the procedures for dealing with multiple casualty incidents and disasters such as a car crashing into the grandstands.

Efficient communication is key to the successful delivery of EMS during a motorsports event. The communication system must be determined and tested prior to any event. Possible options might include yelling, hand signals, colored flags, lights, radios, cellular phones, or even satellites. Ideally, a centralized race control should dispatch all on-track resources to maximize the safety of all medical personnel, fire personnel, drivers, and other safety personnel.

Every motorsports event should have a clear organizational structure that delineates responsibility and authority for the provision of medical services. Most experts recommend using the incident command system for scene management and recommend utilizing the health care professional who is most medically qualified specific to the provision of rendering emergency medical care for patient care.

Standardized documentation of medical care is important for several reasons. The documentation is not only a medical record, but is also a legal, risk management, continuous quality improvement, and research tool.

Due to vested financial and emotional interests, medical personnel tend to treat an increased number of drivers and crewmembers that refuse further recommended medical treatment. Therefore, a procedure must be in place to deal with refusal of medical care both when a patient is competent to refuse care as well as when the patient isn't competent, due to an altered mental status or possible head injury. Many organizations now require that any driver who crashes his vehicle such that he is unable to drive away from the incident is required to be evaluated and cleared by medical personnel.

### Driver and Patient Care

Although all sports medicine involves scene safety and the ABCs, providing medical care during a motorsports event is significantly different from providing medical care at a football game or at a typical car accident.

One must first consider scene safety. Standard practice during many motorsports events is to dispatch fire and medical personnel while vehicles are still racing or at significant speed often only several feet away from rescue personnel. Sometimes this is done to facilitate a rapid response to the driver, whereas other times it is due to the inability to stop a race once it is underway, the time pressures of a live television broadcast, or the desire to keep cars moving around a track via a pace car. The safety of rescue workers, however, must remain the number one priority. In general, medical personnel

should never turn their backs on race traffic, they should use their vehicles to help protect the scene, they shouldn't park directly below crash scenes on banked tracks due to fuel run-off and fire risk, they should understand the sanctioning body's policies for crash responses and cautions, and most importantly they should stop the event if necessary for the safety of the patient, caregivers, or others.

Because there is often more than one vehicle that crashes, immediate triage of racers is typically required. In fact, triage starts even before one is able to access the first racer. For instance, open cockpit racecar drivers remove their steering wheels and stock car drivers are instructed to put their window nets down after a crash to indicate that they are okay. Although the net is sometimes knocked down from an impact, if the net is still up, responding medical personnel should generally stop and evaluate those drivers first. Technology will soon be available that flashes a light on the side pods of Indy cars following impacts greater than predetermined criteria (eg, 50 Gs), thus allowing medical personnel to respond to the vehicles with the highest risk for injured drivers first.

Historically, burns have killed more drivers than anything else. Although fuel cells and other technology have significantly reduced the number of drivers burned, burns are still a significant threat to drivers and rescue workers. Many experts recommend that all EMS personnel be in fire suits when working near race vehicles, especially vehicles such as Indy cars that utilize methanol because it burns invisibly. Due to this characteristic it is also important to realize that a driver that jumps out of an open wheel race car and starts dancing, rolling on the ground or acting crazy for no apparent reason is probably on fire, even though one can't see the flames.

Although the fundamental principles of spine management remain unchanged, medical personnel at races can witness a crash and start evaluation and treatment literally seconds following an incident. Because it takes time for the area around broken bones to bleed and swell, and for the adrenaline to subside, drivers may not have immediate pain following a fracture-producing impact. In my experience, several drivers assessed immediately after impact were found to be alert and oriented, have nontender neck examinations, no focal neurologic deficits, no significant distracting injuries, and they denied neck pain. Yet, these same drivers were later found to have significant unstable cervical spine injuries requiring surgical stabilization. In my experience, racecar drivers often don't start having pain until 5 to 10 minutes following a crash. Although there is literature suggesting prehospital spinal clearance utilizing specific criteria is safe [47-49], none of these studies looked at the motorsports environment. Thus, the recent trend of clearing cervical spine injuries clinically via specific criteria in the field should be discouraged [50] until a driver has been observed for at least 10 minutes following a significant impact. Judgment must be used with drivers that adamantly insist on getting out of their racecars following a significant impact because forcefully restraining a driver could potentially do more harm than good. Cervical

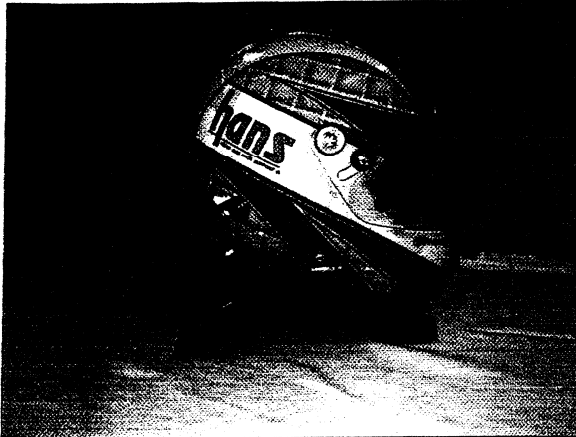


Figure 3. Head and Neck Support (HANS) device and helmet.

spine management has also become more complicated lately due to the increasing use of various head and neck restraint devices (Fig. 3).

In general, it is very difficult to obtain an advanced airway on a driver while in most race vehicles. Most experts now recommend that basic airway adjuncts (eg, oral airway, bag-valve-mask ventilation) be initiated while the driver is still in the car with immediate extrication in full spinal immobilization prior to obtaining an advanced airway. On occasion, however, a driver may have a prolonged extrication or may require an advanced airway be placed while in the race vehicle. Recommended airway techniques for trapped drivers include oral airways, nasal intubations, combitubes, laryngeal mask airways (LMAs), digital intubations, and surgical cricothyrotomies. Blind techniques such as the combitube, digital intubations, or LMA may be particularly helpful when a driver is trapped upside down in a car or in a position that makes direct laryngoscopy impossible. One sanctioning body's rescue team has recently assembled the trumpet airway device. This device uses a conventional bag-valve device fitted with a pediatric endotracheal tube. By inserting a nasal trumpet into the nares through the open helmet shield one can then insert the end of the pediatric tube in the trumpet to provide ventilation until the helmet can be removed. In general, all helmets should be taken off to provide easy access to the airway and a neutrally aligned spine when placed on a backboard.

Breath sounds can be impossible to hear due to the loud noises inherent to motorsports. Thus, multiple methods to confirm appropriate advanced airway placement should be utilized, such as endotracheal CO<sub>2</sub>, direct visualization, pulse oximetry, chest rise and fall, and esophageal detection devices. It is also important to remember that carbon monoxide poisoning should be considered in any drivers after racing in closed vehicles for a prolonged period of time, especially when the vehicle has been damaged.

Cardiac function can be assessed as usual with simple distal extremity pulse checks. Starting intravenous lines,

however, should usually be done once the driver is extricated and loaded into the back of an ambulance or other rescue vehicle and en route to a higher level of care. Interestingly, many drivers die from heart attacks and may injure not only themselves but also other drivers, crew members, or spectators [2]. Driving 2 hours on a road course is equivalent to running 15 8-minute miles [51]. Many experts, therefore, disallow anyone with significant heart problems from competition.

Neurologic assessment of racers has potential pitfalls. Imagine a National Association for Stock Car Auto Racing (NASCAR) driver who crashes. The driver may tell you correctly that it is Sunday and he is at the racetrack. More detailed questions should be asked, however, because the drivers know that they always race on Sundays. If a driver, on the other hand, tells you that it is April 25 and he is at California Speedway and he just crashed in turn four after being "bumped by Rusty" then he probably isn't confused. In general, all unconscious or altered drivers should be extricated with full spinal precautions. It is important to remember that most driver deaths are due to head and neck injuries, and a high index of suspicion should be maintained for such injuries.

Although a few have advocated cutting all clothes off of a driver so no injuries are missed while still in the car, the authors recommend leaving all protective clothes such as fire suits and gloves on a driver until they are in an ambulance due to the continued risk of fire and to prevent a public spectacle. Professional road racing motorcyclists have aerodynamic humps built into their racing leathers that interfere with spinal immobilization and thus should have their humps cut out or removed before being placed on a backboard.

Initial in-car assessment of drivers should include airway, mental status, ability to move arms and legs, and questions regarding pain, numbness, paresthesias, or stiffness in neck and back. If there is ever a question of whether or not a patient requires the vehicle to be cut to safely extricate a driver in full spinal immobilization, the authors recommend the following adage, "If in doubt, cut them out!"

## Conclusions

Motorsports medicine is a rapidly evolving subspecialty with many unique aspects that require specialized education, training, and practice. Those that are interested in learning more about the latest advances in motorsports science should consider joining the International Council of Motorsports Science ([www.motorsportsafety.org](http://www.motorsportsafety.org)).

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